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(71) Applicant (*for all designated States except US*): NORSK HYDRO ASA [NO/NO]; N-0240 Oslo (NO).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): AASEN, Einar, Johan [NO/NO]; St. Edmunds vei 39E, N-0280 Oslo (NO). MORLEY, Edward, James [GB/DK]; Arnumvej 80, DK-6520 Toftlund (DK). MIDLING, Ole, Terje [NO/NO]; Munkhaugv. 32, N-4262 Avaldsnes (NO). SANDVIK, Anders [NO/NO]; Vestre, N-5474 Skjold (NO).

(74) Agent: RICANEK, Ivan; Norsk Hydro ASA, N-0240 Oslo (NO).

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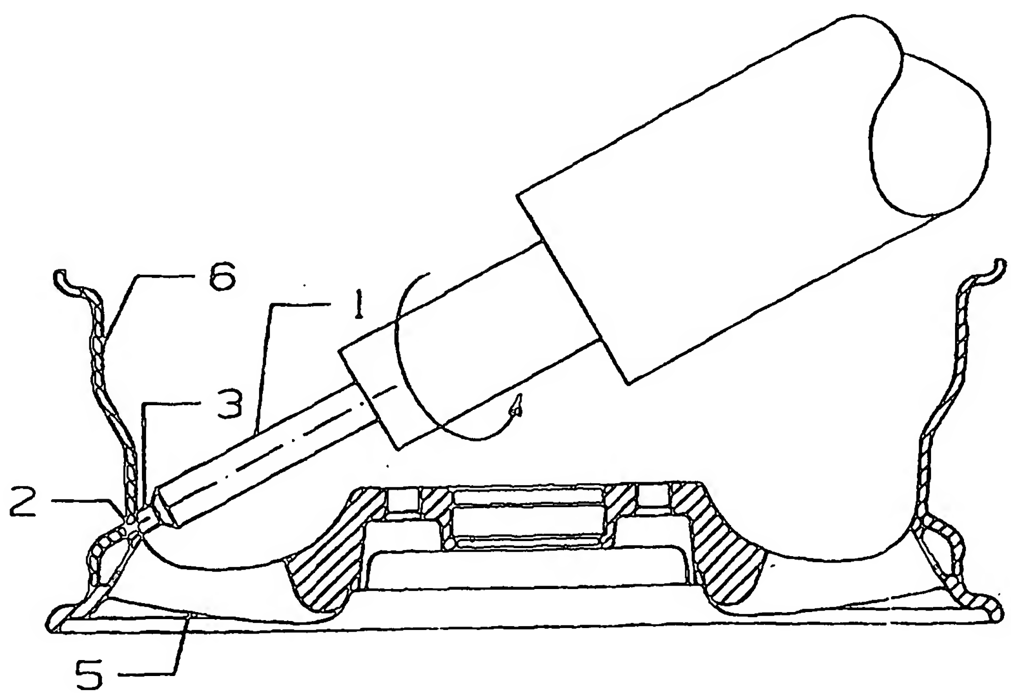
(54) Title: TWO-PIECE WHEEL



(57) Abstract

Light weight two-piece wheel comprising a centre part (5) and a rim part (6) joined together by means of a solid-phase friction stir weld seam.

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"Two-piece wheel"

The present invention relates to light weight vehicle wheels and more particularly to vehicle wheels composed of two or more separately formed parts and a method for forming the same.

Today there are mainly three types of light metal wheels on the market:

- cast one piece
- forged one piece
- welded plate wheels

The forged and welded ones have the biggest potential for low weight because of use of wrought alloys having higher strength than casting alloys. However, casting gives a higher design freedom, without influencing the cost essentially.

The design freedom does not only give styling flexibility, but also makes it possible to give the centre part of the wheel a nearly optimal shape with respect to cornering strength which normally is the critical aspect for this part.

In the rim area, however, an alloy with high mechanical strength and good elongation is of main importance.

An optimal design of a wheel in order to obtain low weight and full styling freedom thus seems to be one where a cast centre part is joined to a rim of wrought alloy.

Such wheels are already on the market and have joints either comprising a bolted connection (being an expensive and non-low-weight solution) or a weld seam.

However, all hitherto known/disclosed welding methods for wheels are based on fusion welding (e.g. arc welding) or friction welding which requires joint preparation and post weld dressing steps, something which negatively influences the total manufacturing costs. Furthermore, several other negative/limiting aspects have been experienced, such as environment hazard connected to fusion welding, problems with dimensional stability both with fusion and friction welded wheels and limited design freedom with regard to the need for performing multiple parallel welds compared to conventional friction welding processes.

It is therefore an object of the present invention to provide a new and improved type of two-piece wheels avoiding the above drawbacks related to the presently applied joining methods.

Another object of the present invention is to provide a new method for joining of separately formed wheel parts offering the possibility to achieve high quality weld seams.

These and other objects and advantages of the present invention are met by provision of a solid-phase friction stir weld between the separately formed wheel parts and becomes apparent from the following detailed description of the preferred embodiment(s) when read in the light of the accompanying drawings, Figures 1-4, where

Fig. 1 shows schematically in a plan view joining (welding) of the assembled two-piece vehicle wheel,

Fig. 2 is a cross-sectional fractional vertical view of a vehicle wheel fabricated in accordance with the present invention,

Fig. 3 shows in a cross-sectional fractional view a vehicle wheel exhibiting an alternative configuration of the weld seam, and

Fig. 4 is an enlarged view of a selected portion of Fig. 3 illustrating a weld joint geometry for joining the disc part to the rim part of the wheel.

Referring to the drawings, and particularly to Fig. 1, the principle of joining separately provided rim part 6 and centre part 5 of a vehicle wheel by means of a rotating tool 1 is shown schematically to illustrate application of the friction stir welding process according to the present invention.

The recently developed friction stir welding process, as disclosed in WO93/10935, joins workpieces by plasticising and then consolidating the material about their joint line. The welding is achieved by means of a rotating tool 1 comprising a pin 2 and a shoulder part 3, where the pin is inserted at the start of the joint line 4 and moved forward in the direction of the welding. When the pin is rotated, it friction heats annular regions of the pre-assembled workpieces rapidly producing a shaft of plasticised metal around the pin. As the pin is moved forward, the pressure provided by the leading face of the shoulder part 3 forces plasticised material behind the pin where it consolidates and cools. Thus no heat is generated due to a relative motion between the workpieces to be joined.

The pre-assembled wheel parts 5,6 can advantageously rotate during the welding process around their vertical axis of symmetry, while the rotor tool 1 remains stationary as indicated in the figure. In this way more than one weld seam can be achieved simultaneously using a double set of friction stir welding rotor tools.

Special advantages resulting from application of the friction stir welding process for joining of separately made vehicle wheel parts according to the present invention are more apparent from Fig. 2 and Fig. 3 which show an optional choice of lap or butt weld seams joining a cast or forged outer flange to the centre part.

The possibility of providing two or more parallel seams between the disc part and the rim part results in superior design and wheel performance characteristics compared to the conventional friction welded two-piece wheel.

Provision of "branched" circumferential connection between the disc and the rim ensures a favourable load transfer through the two weld seams in a particularly stressed area of the wheel. Simultaneously an optimal configuration of the disc part is achieved exhibiting a cavity (pocket) 8 at the disc periphery, thus ensuring material and weight savings.

Fig. 4 illustrates in detail a weld joint geometry incorporating a support function for the rim part under the assembling and welding operation. Such joint design considerably facilitates the requirements for fixation means/procedures prior to the welding operation.

Welding tests have demonstrated provision of weld seams exhibiting good mechanical properties with low grade of distortion due to the low heat generation during welding, conducted at approximately 500°C.

Fine grain structures are obtained on all tempers of aluminium alloys whether provided as cast, rolled or extruded parts. Thus, e.g. by welding in solution treated (T4) condition of AlMgSi1 parts followed by artificial ageing (T6 treatment) high uniformity of mechanical properties across the welds maintaining 90% of the original strength in the heat affected zone were achieved, something being unattainable by conventional competitive welding techniques.

The possibility to combine wheel parts made of casting alloys (e.g. AlSi11,AlSi7Mg) with parts of wrought aluminium alloys of 6000 and 7000 series is another advantageous feature of applying the friction stir welding process according to the present invention.

According to a preferred embodiment a two-piece wheel can be provided combining a centre part and a rim based on a centrifugally cast tube of wrought aluminium alloy which is subjected to plastic working (roll or spin forming) to the desired configuration of the rim profile prior to the weld joining of the parts. In this way an optimal combination of material characteristics is achieved, thus reducing the danger of cracking during the plastic working of the rim.

Further benefits and advantages resulting from applying friction stir welding in manufacturing of two-piece wheels are as follows:

- no special preparation of the to-be welded surfaces is required and there is a possibility to weld prefinished parts which have been surface treated (powder coated or anodised),

- welds have good surface appearance and require no or limited post welding machining or dressing operations,

- the process is energy efficient and can be performed on inexpensive equipment,

- good dimensional tolerances (run out) due to a low distortion,

- no filler material, special operative skill or shielding atmosphere is required,

- there is no loss of alloying elements from weld microstructure compared to fusion welding techniques and fine grained seam indicates maintenance of wear base material fatigue properties,

- and finally it is an environmentally friendly non-polluting process of manufacturing vehicle wheels.

Other than the above by way of examples disclosed configurations of wheel parts and weld joints can be applied within the frame of the present invention. Thus, e.g. the centre part may be provided as a forged part of a wrought Al-alloy or a centre part of spider type comprising a multiplicity of hollow spokes instead of the illustrated full face centre part.

Claims

1. Automotive light metal two-piece wheel comprising a wheel centre part (5) and a rim part (6) interconnected by at least one circumferential weld joint,

   characterized in that

   the welded joint is a solid-phase weld seam provided by friction stir welding exhibiting fine grained structure seam and minimal heat affected zone along the weld seam.

2. Automotive wheel according to claim 1,

   characterized in that

   the weld seam is formed between a centre part of cast alloy and a rim of wrought alloy.

3. Automotive wheel according to claim 2,

   characterized in that

   the wrought rim of the wheel is based on a centrifugally cast tube being roll- or spin-formed into the final rim configuration.

4. Automotive wheel according to any preceding claim,

   characterized in that

   both parts of the wheel are made of wrought Al-alloy.

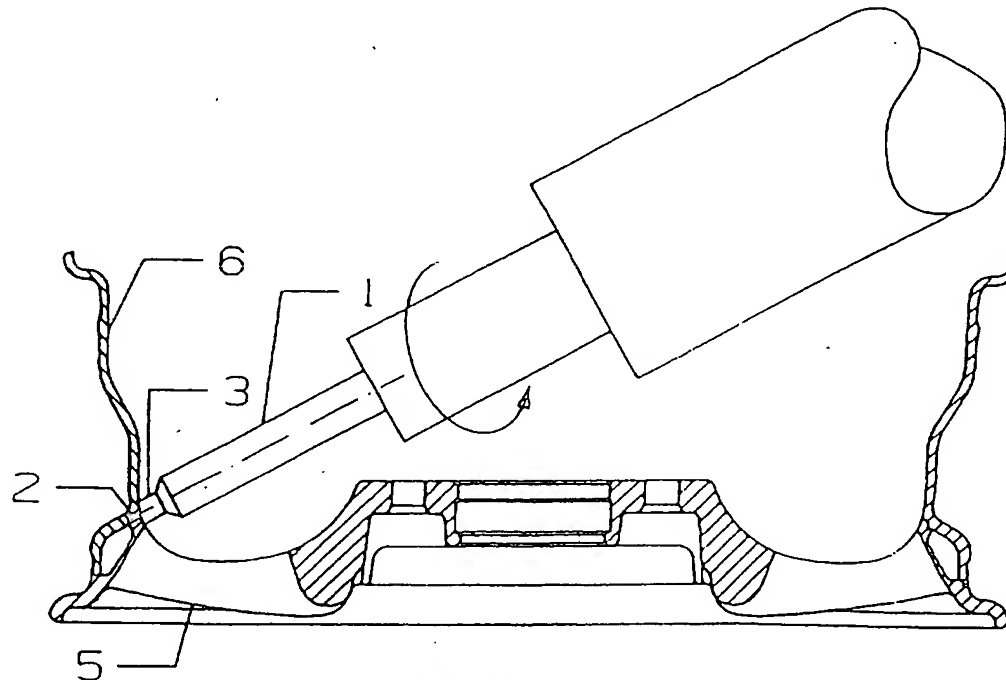

Fig. 1

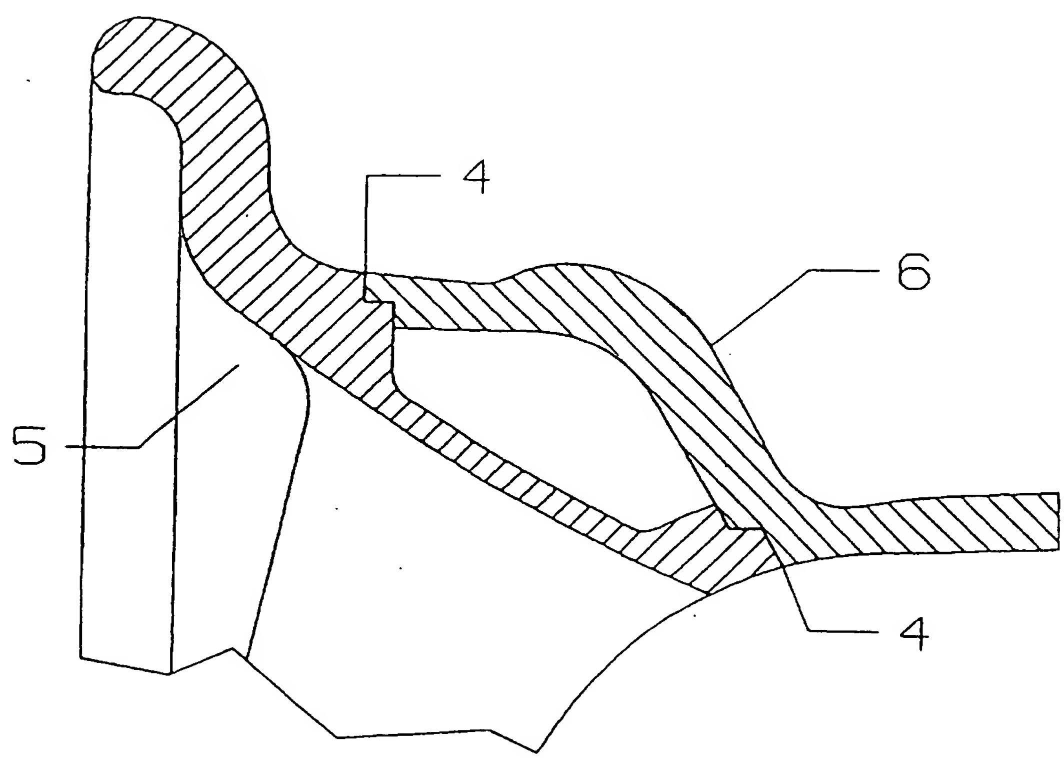

Fig. 4

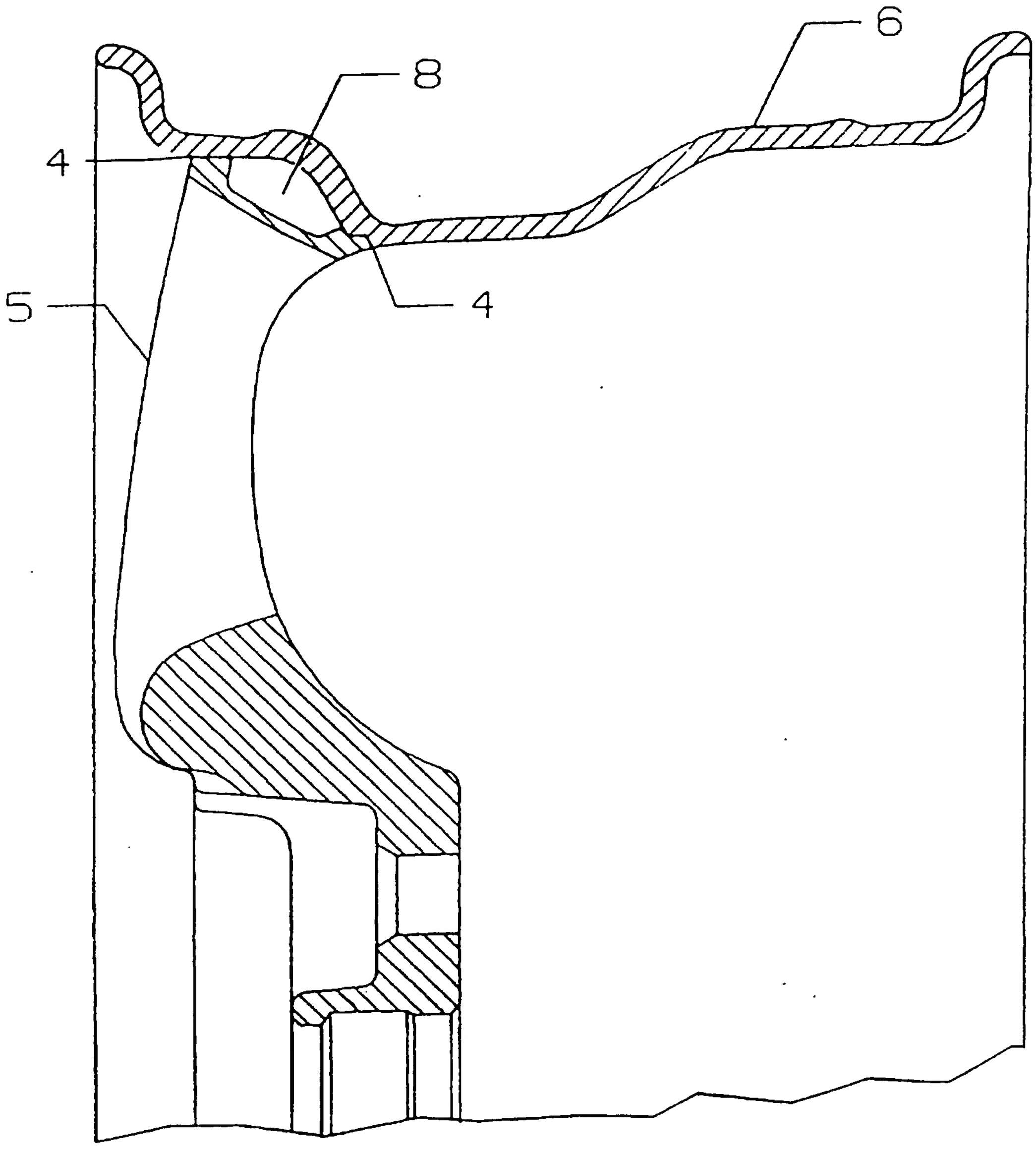

Fig. 2

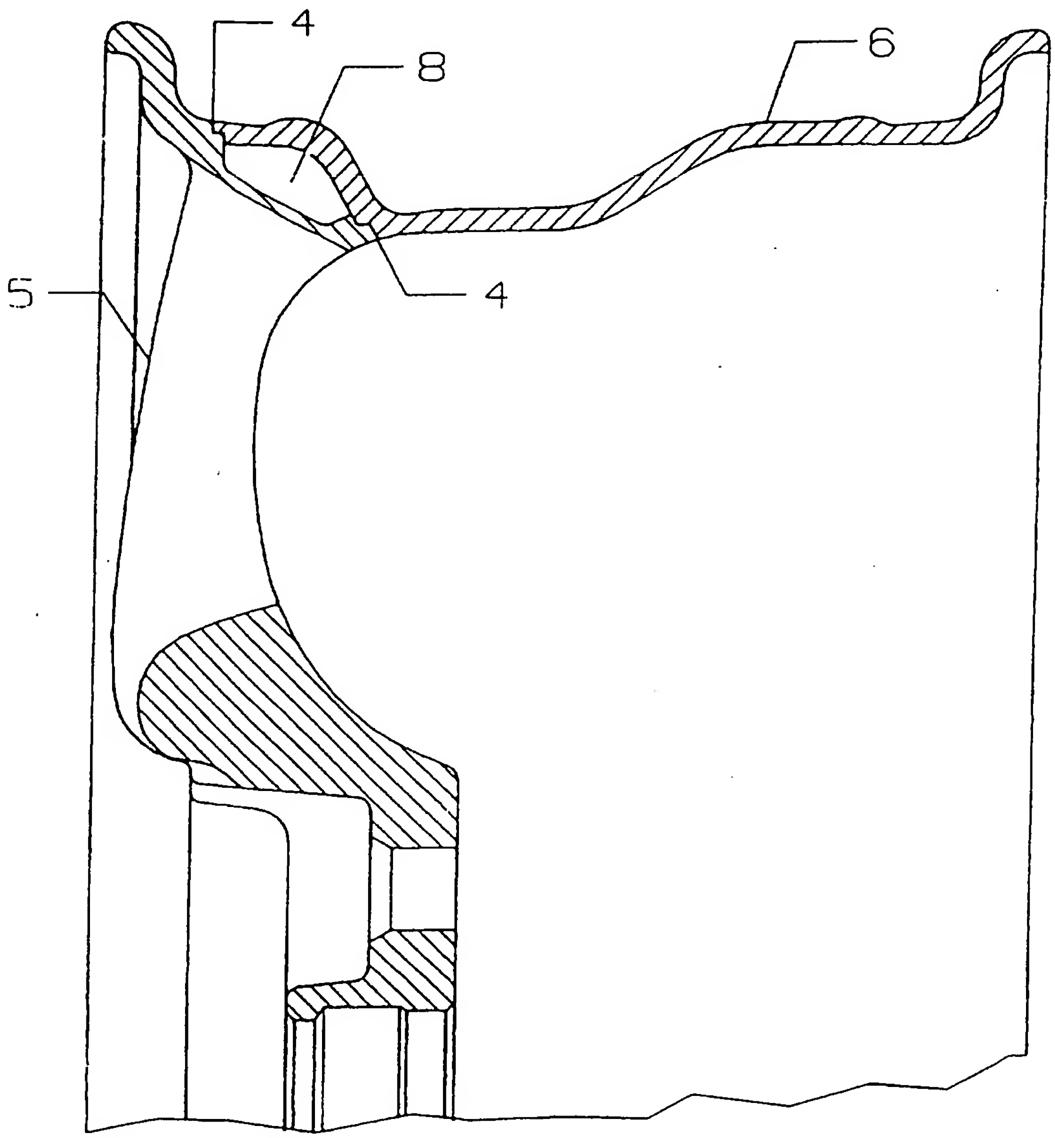

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 96/00254

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B60B 23/00, B23K 20/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B60B, B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0547313 A2 (H.C.F.PORSCHE AKTIENGESELLSCHAFT), 23 June 1993 (23.06.93) --	1
A	WO 9310935 A1 (THE WELDING INSTITUTE), 10 June 1993 (10.06.93) --	1
A	WO 9526254 A1 (NORSK HYDRO A.S.), 5 October 1995 (05.10.95) -- --------	1

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

28/10/96

International application No.
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